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Superconductors made by Atomic Layer Deposition

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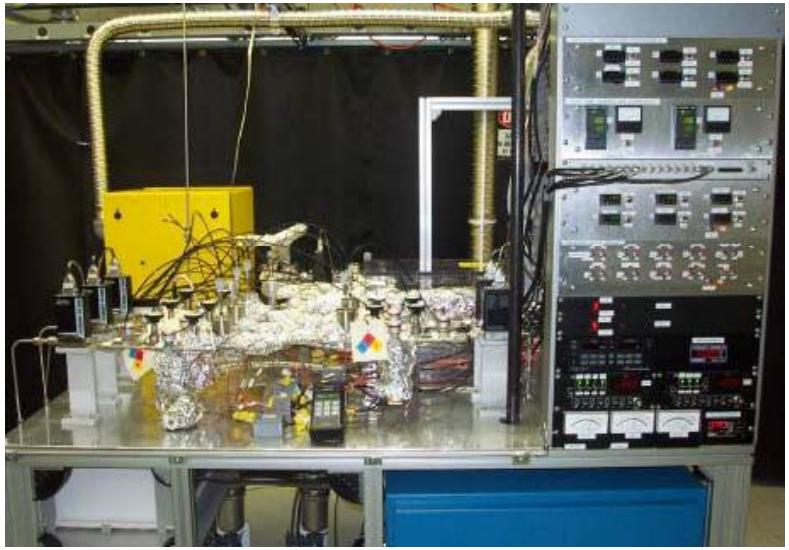
Soon Ph.D Nick Becker

6th SRF workshop
Tallahassee FSU

Superconductors by Atomic Layer Deposition

- -Conformal: Not line of sight
- -Thickness control Atomic layer
- -Chemistry



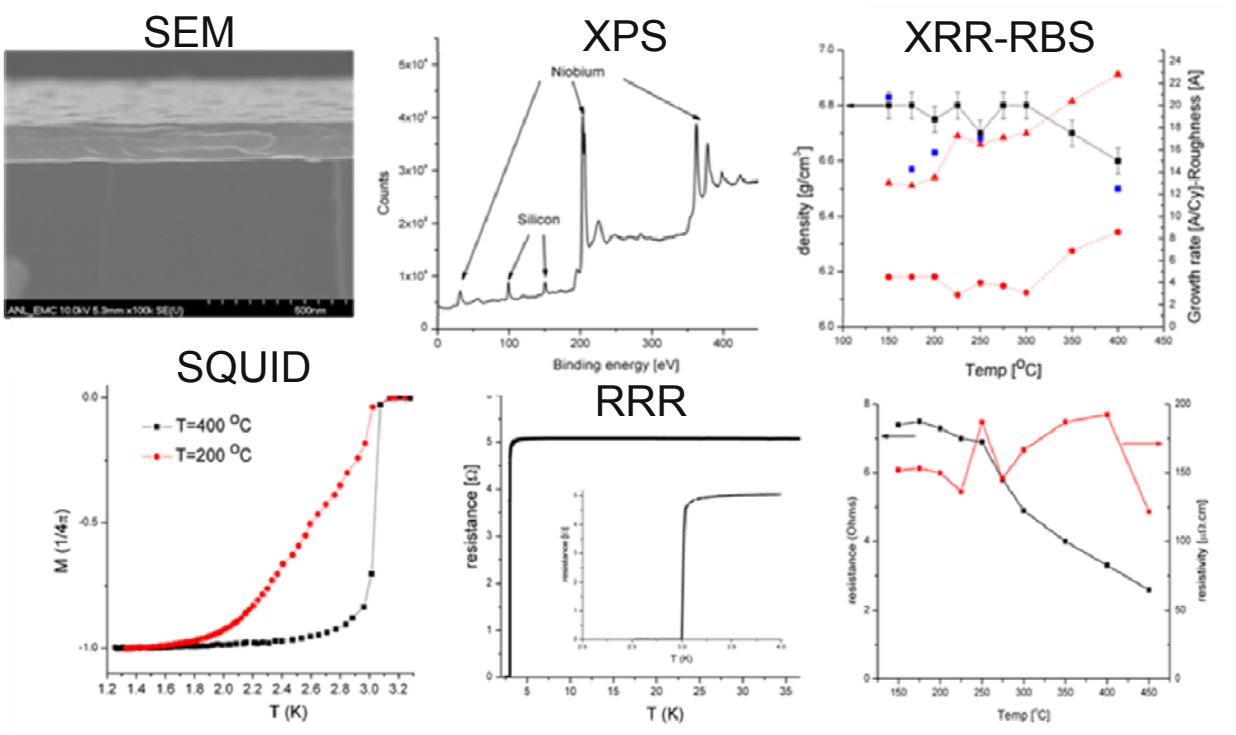
-Dedicated ALD system for superconductors

-High temperature precursors delivery

-Ordered the plasma ALD system

Superconductors Atomic Layer Deposition:

$NbF_5 + Si_2H_6 = NbSi$ + reaction product, copy on : $WF_6 + Si_2H_6 = W + SiHF_3$



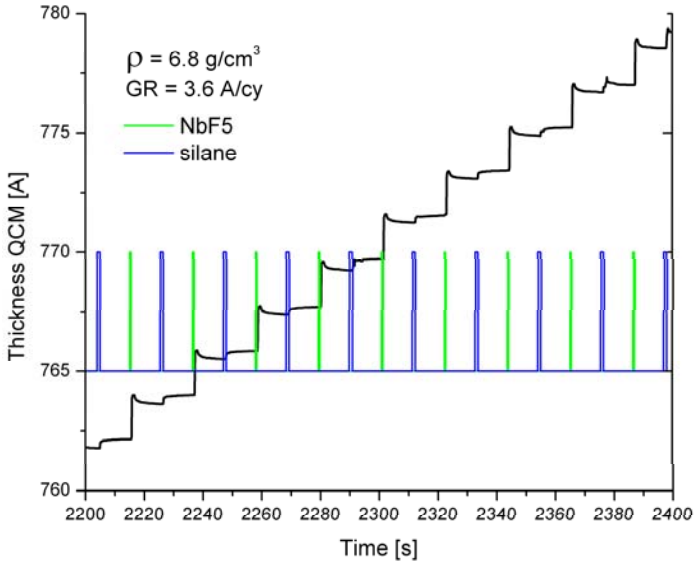
Fast growth rate:
2.1 Å/Cy

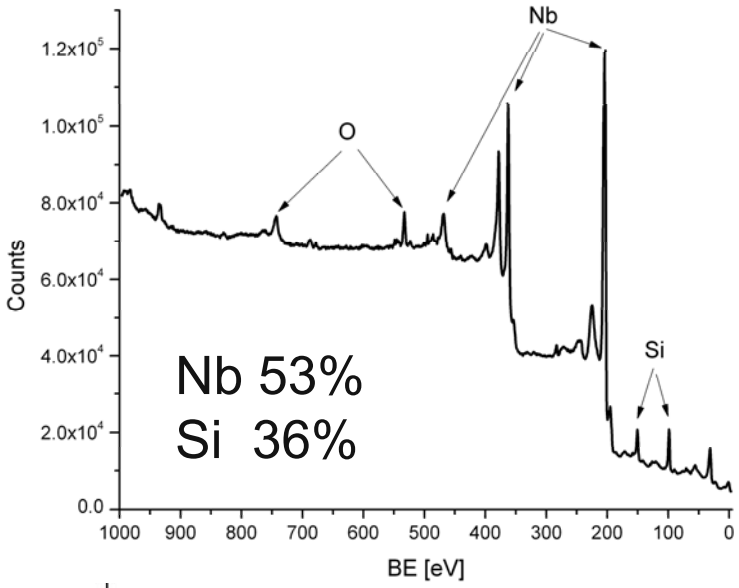
Grows only W
Not on oxides

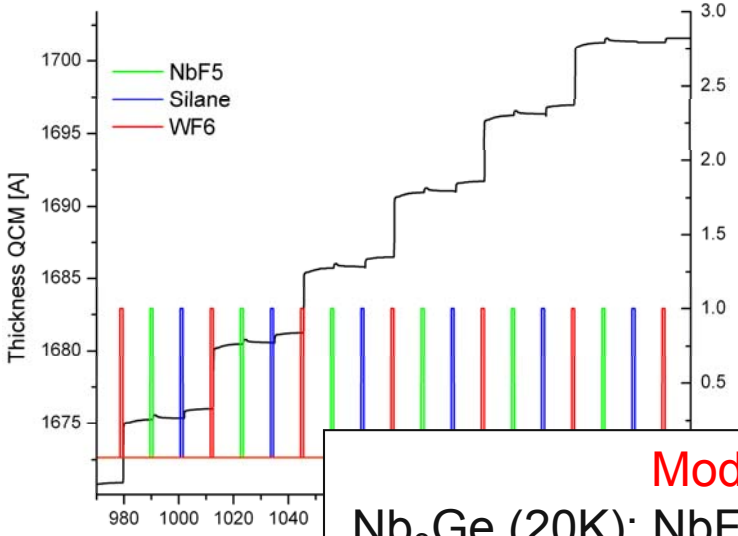
$NbF_5 + SiH_4 = NbSi$ too

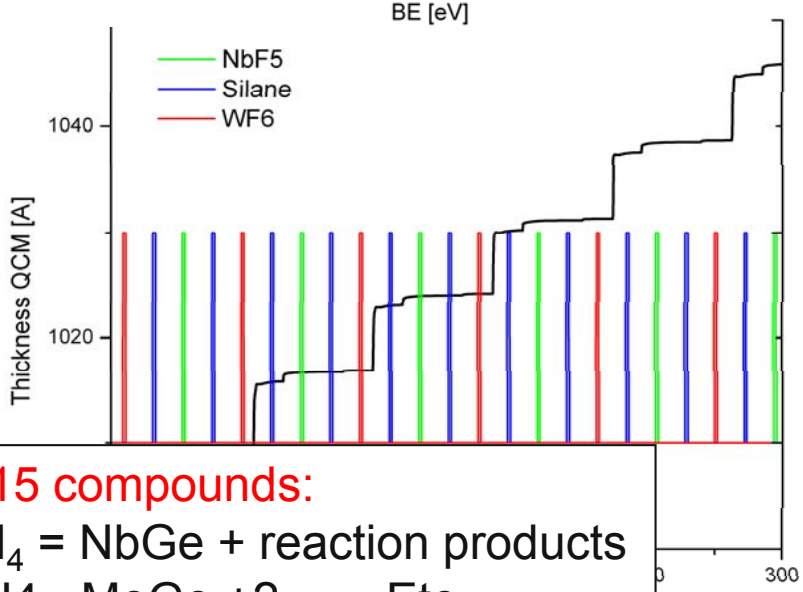
$NbF_5 + SiH_4 / WF_6 + SiH_4$

Superconductors Atomic Layer Deposition:







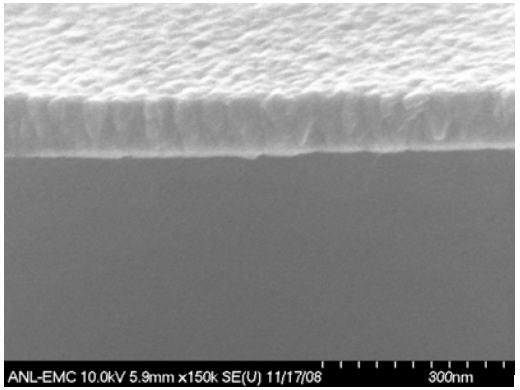


Model for A15 compounds:

Nb_3Ge (20K): $NbF_5 + GeH_4 = NbGe$ + reaction products

MoGe (12K): MoF6 + GeH4 =MoGe +? Etc…

Superconductors Atomic Layer Deposition:

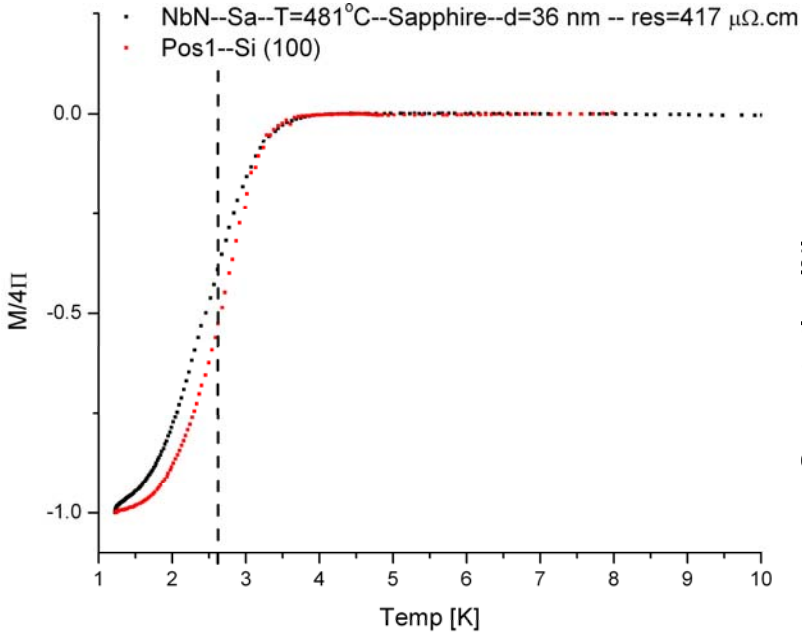


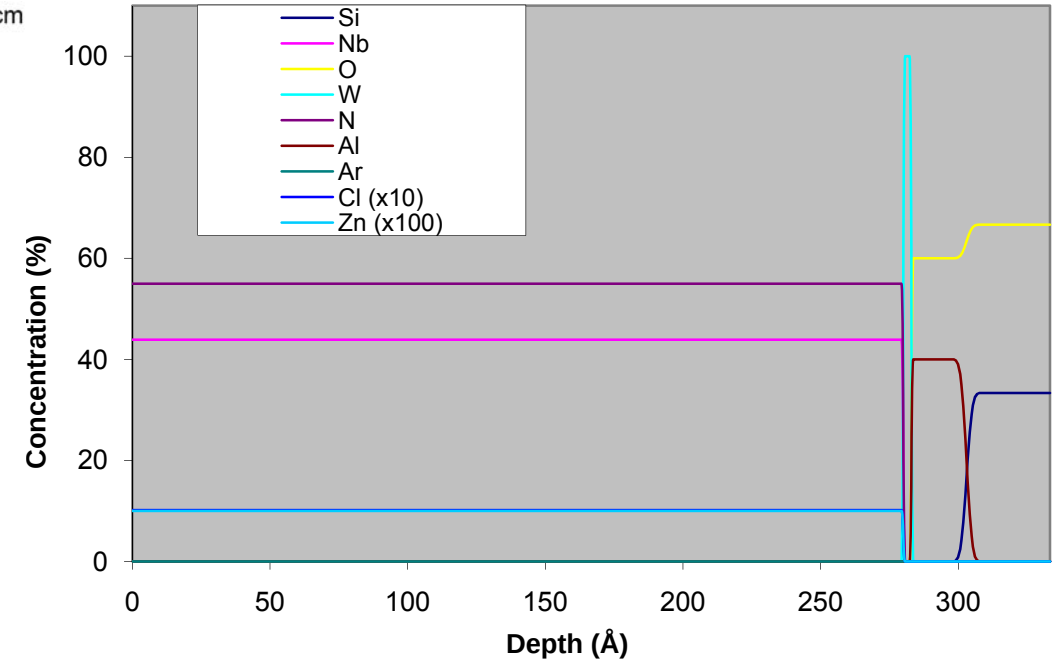
- New precursor NbF_5 for NbN, Nb_2O_5 grows much faster!
- Zinc pulse growth for NbN and TiN:

$$NbCl_5 + NH_3 + Zn = NbN + ZnCl_2 + HCl$$

TiN films: resistivity ρ=50 μΩ.cm for 10 nm films! (350 without Zn)

NbN films: resistivity ρ=200 μΩ.cm (450 without Zn -> Tc= 5.5 K, Cl=3-10%).

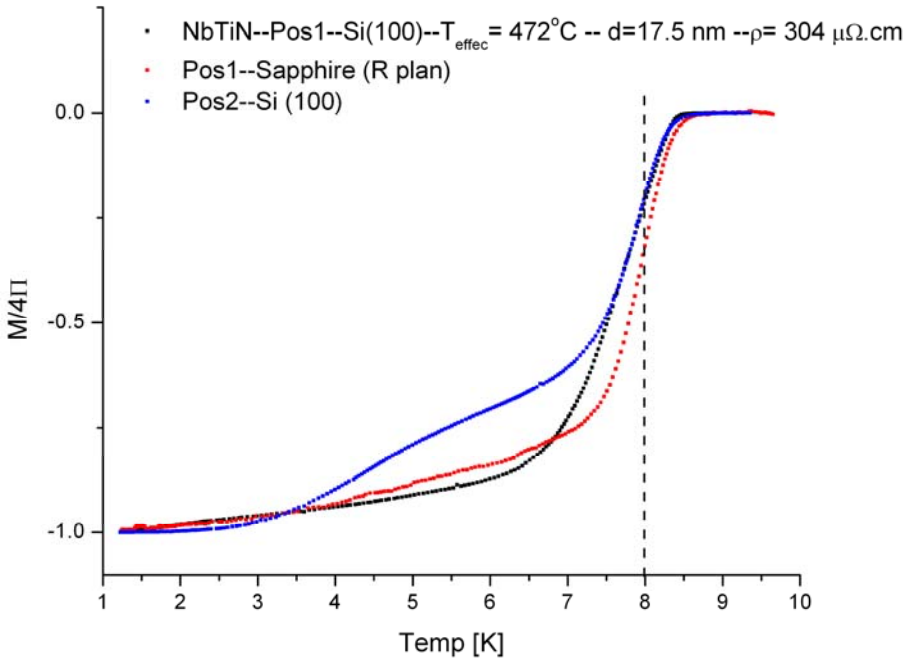




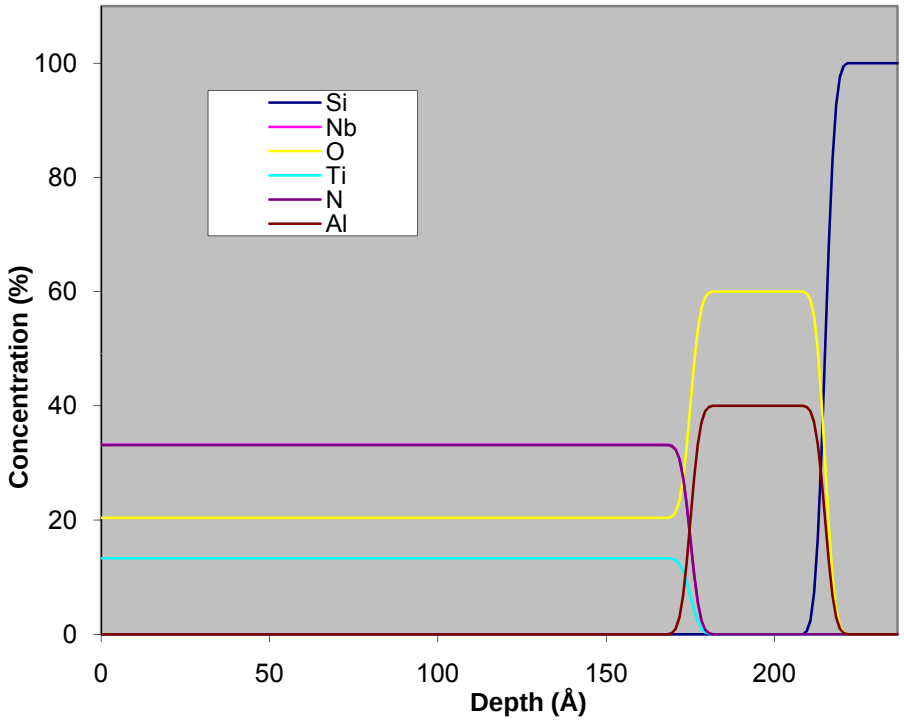
$Nb_{0.55}N_{0.44}Cl_{0.01}$

Superconductors Atomic Layer Deposition:

$NbTi_xN$



$Nb_{0.32}Ti_{0.13}N_{0.32}O_{0.22}$



XRR -> 17.5 nm film -> Nb Tc is 7 K

XPS -> NbN ; TiO_2 -> $NbNTiO_x$

$(NbCl_5 + Zn + NH_3) + 2*(TiCl_4 + Zn + NH_3)$

Superconductors Atomic Layer Deposition:

Structural analysis -> XRD going on

High Ox concentration after one thermal cycling -> leaks at gaskets
We know how to fix it: welded assembly + N_2 gas filter

Tried: $NbCl_5$ + Zn -> Nb…// $SnCl_4$ + Zn -> Sn…// $TiCl_4$ + Zn -> Ti
Failed….other chemistry is required for Thermal ALD.
$NbCl_5$ + Zn + NH_3 / $SnCl_4$ + Zn + NH_3

-Keep working on Nitrides and optimize NbN and NbTiN

-And work out MgB_2 with Borane and organic precursors

-Building collaboration with chemist from ANL and IIT to make new precursors:
Alkylsilyl family for instance to form Se/Te compounds.